

season of greatest rain is slightly later and the amount is greater at points favorably situated with respect to the sea winds. On the other hand, places in the rain shadow of the mountains receive less rain than on the coast.

In Bahia the inland type as represented by the station Caetité is nearly opposite to the coastal type in that the greatest rains occur in the months November–April and the least in winter June–August.

With increasing distance from the Equator the monthly distribution tends toward the equality of the Temperate Zone, although distance from the sea and topographic factors are still controlling influences. The three stations in São Paulo whose graphs are given in Figure 1—Santos on the coast, Alta da Serra, a seaward-facing slope station about 15 kilometers inland, and São Paulo on the interior highlands about 50 kilometers inland—show a considerable difference in the monthly distribution. Santos on the coast has a chief maximum in March, while the slope station, Alta da Serra, has a decided maximum in the summer months, December to February. The total annual amount of rain at that station is, moreover, the greatest reported for any station in Brazil, doubtless due to the topographic factor. The concluding group of interior stations beginning with Juiz de Fora and concluding with Cuyaba illustrate the characteristics of monthly distribution in the interior of the States of southern Brazil. A feature common to all of them is a rainy season in summer and a dry season in winter.

MAXIMUM PRECIPITATION IN 24 HOURS.

Voss, speaking of the maximum precipitation in Brazil for 24 hours, says:⁵

By far the greatest rainfall within 24 hours fell in the State of São Paulo, Brazil, on the eastern slope of the Serro do Mar at an elevation of 230 meters at kilometer No. 22, on the wire-cable railroad Santos to São Paulo. Here on March 29, 1898, a rainfall of 417 millimeters (16.42 inches) occurred. At just double the elevation at kilometer 25.2, 313 millimeters fell on the same day and at the end of the line, elevation 800 meters, the fall was only 61 millimeters (2.40 inches).

The record of maximum rains in 24 hours in Doctor Ferraz's bulletin refers, of course, to the period 1909–10. I have summarized the data by States and present the results in the table below. The arrangement of States is in the order of magnitude of the 24-hour rains.

TABLE 4.—Maximum precipitation in 24 hours (by States).

States.	Amount.		States.	Amount.	
	Milli- meters.	Inches.		Milli- meters.	Inches.
S. Catharina.....	288.3	11.39	Alagoas.....	162.7	6.40
Maranhão.....	222.7	8.76	Goyaz.....	160.0	6.30
Minas Geraes.....	202.7	7.98	Parana.....	153.0	6.02
Ceara.....	201.9	7.95	Pernambuco.....	146.1	5.78
Amazonas.....	201.0	7.91	Matto Grosso.....	133.6	5.25
Bahia.....	193.0	7.60	Rio Grande do S.....	133.4	5.25
Para.....	177.6	6.99	Sergipe.....	122.1	4.81
Rio Grande do N.....	174.0	6.85	Parahyba.....	119.0	4.68
Rio de Janeiro.....	173.0	6.81	São Paulo.....	98.4	3.87

⁵ Voss, Ernst Ludwig, Die Niederschlagsverhältnisse Südamerika, Ergänzungsheft No. 157 Petermanns Mitteilungen. S. 30.

THE ETESIENS.

By J. S. PARASKÉVOPOULOS.

[National Observatory, Athens, Greece, May 25, 1922.]

Introduction.—The characteristic north winds which blow during the summer in the region of the eastern Mediterranean, are known as the etesiens. The periodic nature of these winds has been observed since the time of the ancient Greeks, their marked regularity being noted by Hesiodus. In fact, it is because of this characteristic regularity that they are called etesiens.¹ The name itself means "winds blowing periodically every year." Aratus has written on this subject in his *Phenomena*, from which we quote the following:

When the corn has been harvested and the sun is approaching the constellation of Lion, then the etesiens blow with their full strength in the open sea; navigation with oars is not possible and I want then a large boat.

Theon, the commentator of Aratus, explained the name in a double way:

The etesiens blow from the time of the morning rising of the constellation of Canis Major, during, at the most, 60 days. They are called etesiens either because they blow each year during certain days, or, more truly, because they are sure to blow when their season comes. At that time, large boats are necessary, because the waves are high and the wind stormy.

Characteristic features of the etesiens.—The method of determining the period during which etesiens blow in Greece has been as follows: I have divided the month into 10-day periods and noted the number of days during which etesiens have blown in each period rather than counting the number of days in each month. This method has been applied to observations extend-

ing over 15 years (1900–1914) and is based on the observations made at the Greek meteorological stations. At these stations observations are made three times daily; at 8 a. m., 2 p. m., and 9 p. m. (Athens mean time). I have selected four stations in the Aegean Sea (Andros, Syra, Naxos, Santorin) and three in the Ionian Sea (Corfu, Zante, Cephallonia). For the station at Athens I have used observations from self-recording apparatus.

Table 1 gives the average number of days having north winds. I have considered as north winds all winds between the directions ENE., N., WNW.

In examining the tabulated results, especially those from the stations of the Aegean Sea and Athens, I found that these summer north winds fall into two definite periods. The maximum of the first period, which is also the shorter, occurs during the last 10 days of May while the maximum of the second period takes place during July and August. The etesiens are thus divided into two classes known as *prodroms* and *etsiens*. Generally speaking etesiens blow from the second 10-day period of May until the middle of October, with two periods of maximum, as just mentioned.

During the first period the etesiens are less strong and more intermittent than during the second. During June these winds are interrupted, and not very frequent. In July and especially in August they are, on the contrary, much more steady and frequent but their occurrence diminishes continually throughout September and October. This distinction was observed as early

¹ The etesiens are known in the Orient under the Turkish name *meltem*.

as the time of Aristotle who writes as follows regarding the etesiens:²

TABLE 1.—Average number of days with north winds,¹ 1900–1914.

Month.	Athens.	Aegan Sea.				Ionian Sea.		
		Andros.	Syra.	Naxos.	San-torini.	Corfu.	Argo-stoli.	Zante.
	d.	d.	d.	d.	d.	d.	d.	d.
May 1-10.....	5.1	5.3	6.3	6.7	5.8	4.0	6.1	6.4
11-20.....	4.7	5.1	6.0	7.5	5.5	4.7	7.5	7.6
21-31.....	7.2	7.3	8.2	8.6	7.1	6.1	8.3	7.7
June 1-10.....	4.7	5.6	6.7	7.0	5.7	4.5	7.5	7.9
11-20.....	5.1	6.5	6.1	8.5	5.4	5.7	8.4	8.1
21-30.....	5.9	8.1	8.4	8.9	7.4	6.3	8.9	8.9
July 1-10.....	5.3	7.8	8.5	8.5	7.5	5.7	9.1	8.7
11-20.....	6.4	8.8	8.4	9.3	8.4	6.5	9.0	9.6
21-31.....	8.4	10.3	10.3	10.7	9.6	6.4	9.8	9.9
Aug. 1-10.....	7.3	9.3	9.3	9.7	9.1	6.4	9.3	8.8
11-20.....	7.3	9.0	9.2	9.2	8.5	5.5	9.1	8.7
21-31.....	8.7	10.3	10.1	10.8	10.1	6.0	9.5	9.9
Sept. 1-10.....	7.0	8.7	8.9	9.3	8.9	4.6	8.4	8.7
11-20.....	6.4	8.3	7.7	9.0	7.7	4.3	7.1	7.9
21-30.....	7.0	8.0	7.9	8.7	8.3	4.6	7.9	7.6
Oct. 1-10.....	6.1	6.2	6.7	7.9	7.1	4.1	7.8	6.8
11-20.....	6.7	7.1	7.7	8.1	7.7	4.1	6.2	6.3
21-31.....	7.4	7.1	8.1	8.7	8.3	3.5	6.2	6.9

¹ In this table, winds of directions between ENE.-WNW. have been considered as north winds.

That is why during the time of the morning rising of Orion there is calm until the time of the etesiens and the prodroms.

The etesiens blow after the solstice and the morning rising of Sirius, they do not blow when the sun is nearest or when it is farthest away; they blow during the day and cease at night.

According to the ancients, therefore, the principal etesiens begin simultaneously with the morning rise of Sirius, i. e., about the middle of July. Unfortunately, I could not find any reference in ancient literature to the period of the prodroms, so that in this case we are obliged to draw our conclusions entirely from our recent anemometric observations. A careful examination of the following quotation from Aristotle shows that in all probability the prodroms were confused with the principal Ornithiens winds:

In the same way, after the time of the winter solstice the ornithiens blow; these winds are weak etesiens; they blow less and later than the etesiens; they begin to blow on the seventieth day because the sun is far away and strengthens them less; they do not blow continually like the etesiens because at that time only the surface frost is melted whereas the deeper frozen parts need more heat. That is why the ornithiens blow intermittently until the summer when the etesiens blow.

There is of course a variation from year to year in the beginning and duration of the etesiens but in general the dates are as indicated above. Indeed, it occasionally happens that the etesiens are replaced by winds of other directions for periods as long as a month.

Table 2, which follows, gives the number of days during which etesiens have blown in Athens during the years 1900–1914, inclusive, and also the distribution of the dates in the 10-day periods of the month.

Prodroms.—According to Table 2 the prodroms blow during the end of May and the beginning of June. They prevail for one or two weeks at most and even then are interrupted by winds of local origin. At the end of the first 10 days of June they give place to the sea breeze or other local winds which prevail until about the middle of July when the real etesiens begin. The end of the prodroms is more abrupt than the beginning and they are the most frequent during the last 10 days of May. The north winds of May are, we would say, rather erratic. For example, in May we had north winds:

- (1) During the beginning of the month in 1905 and 1907.
- (2) Almost continuously during the whole month in 1909.
- (3) At intervals during the month in 1908 and 1911.
- (4) During the end of the month in 1904 and 1910.
- (5) Not at all during the entire month in 1902 and 1904.

This irregularity of the prodroms justifies our opinion that they are the ornithiens mentioned by the ancients which, according to Aristotle, "blow intermittently until the summer solstice when the etesiens blow."

TABLE 2.—Actual number of days of etesiens in Athens.

Year.	May.		June.		July.		August.		September.		October.	Total.
	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	
1900.....	0	0	1	1	5	6	8	5	5	7	6	57
1901.....	1	0	0	1	2	3	9	5	7	5	1	48
1902.....	1	2	0	1	5	6	8	7	4	6	9	60
1903.....	4	1	0	0	1	5	5	8	8	8	4	57
1904.....	5	1	4	5	9	9	9	8	7	4	5	77
1905.....	0	0	0	6	10	5	9	10	10	6	7	71
1906.....	1	0	2	7	2	4	7	8	7	7	10	60
1907.....	2	0	1	8	4	0	7	9	7	11	7	81
1908.....	6	3	6	2	4	5	2	6	2	10	5	60
1909.....	4	2	1	2	0	7	14	5	6	2	1	49
1910.....	2	0	0	3	1	0	8	3	7	9	3	47
1911.....	0	3	1	6	6	5	10	2	4	7	8	57
1912.....	1	5	3	2	4	4	5	3	4	2	4	41
1913.....	2	6	2	1	0	0	1	0	5	1	0	21
1914.....	0	0	2	1	1	2	2	5	4	3	3	25
Mean....	1.9	1.5	1.4	3.1	3.6	4.1	6.7	5.6	5.9	4.9	3.9	54.1

Etesiens.—As we have already noted the ancients considered that the beginning of the etesiens occurred about the middle of July, simultaneously with the morning rise of Sirius. The accordance of their conclusion with recent data indicates their observational abilities. The atmospheric condition which gives rise to the etesiens and which we will discuss a little later develops gradually rather than abruptly. About the middle of July it reaches a point where it becomes the prevailing condition. For this reason the etesiens at that time attain their full strength and blow continuously for several days at high velocity and without interruption by local winds.

During the period of development of this atmospheric condition causing the etesiens, these winds are present but without strength and only at intervals. In Athens, for instance, before the middle of July, the etesiens blow during the morning and are replaced in the afternoon by the sea breeze.

Because of this preliminary period we must consider as the date of beginning of the real etesiens not the middle of July but the middle of June when the prodroms stop and a new atmospheric condition favorable to the etesiens begins to develop. The real etesiens, therefore, begin to blow at intervals from the middle of June and gradually accumulate strength until the middle of July when they become the prevailing winds. Their greatest frequency is during the last 10 days of July and all of August. They continue with less frequency during September and are rare in the beginning of October. In July and August they often blow continuously for from 8 to 15 days. During the most favorable years they have been recorded as blowing for 27 or 28 consecutive days.

Mr. Krugler in his valuable study *Die Windverhältnisse im östlichen Mittelmeer und seinem Randgebieten* (p. 66) states that the etesiens are rare in September. As a matter of fact their frequency during that month, though

² The Turks call the prodroms, *keras-meltem*, and the etesiens, *karpooz meltem*. (*Keras*=cherry, i. e., the fruit which is in season during the time the prodroms blow. *Karpooz*=watermelon, i. e., the fruit which is plentiful in July and August when the etesiens blow.)

not so high as in July and August, is rather marked. Mr. Krugler notes that the number of days of the etesiens yearly is 33 while actually this number often exceeds 50. The real etesiens cease during the beginning of October. We frequently have during this month, it is true, north winds but neither do they show the characteristic features of the etesiens nor do they arise from the same atmospheric condition. On the open sea as, for example, in the Aegean, the etesiens are more frequent and more regular than in Athens. Very often in the summer months the sea breeze may blow in Athens while the etesiens prevail in the islands of the Aegean reaching Attica 10 miles north of Athens. There are also yearly variations in the etesiens. During some years the entire month of July or August or September is without etesiens and the velocity also is not a constant quantity each year.

Theophrastus writes as follows on this subject:

Sometimes the etesiens blow strongly and continually and sometimes less and at intervals, because the melting becomes abnormal.

velocity of these winds undergoes a very distinct diurnal oscillation, analogous to the oscillation of the sea breeze. It is rather strange that the etesiens, although due to general causes, as we shall see later, present very local features, which help to distinguish them from the regular north winds. Their velocity increases almost abruptly in the morning and remains the same with small variations until the afternoon, when it begins to decrease until the night. During the night they almost cease or they blow with a very small velocity.

In Athens the speed of the etesiens during the daytime varies from 5 to 12 meters per second (11–27 miles per hour). During July and August it often reaches 15 m/s. during the time of the highest temperature. In the open sea the velocity is higher. In Athens it very seldom reaches 20 m/s. (45 miles per hour). During 5 consecutive days in 1914 (August 9–13) the etesiens blew in Athens with the speed of storm winds, having a velocity oscillating between 20–21 m/s. (45–47 miles per hour).

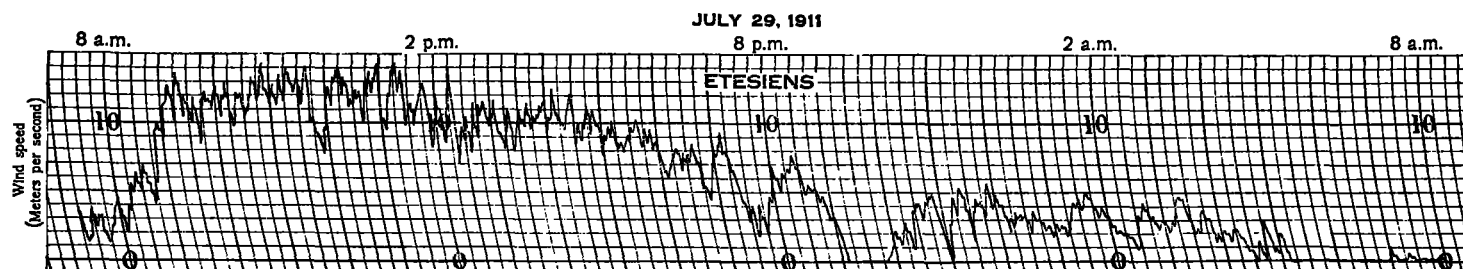


FIG. 1.—Anemocinemographic record from the National Observatory at Athens for July 29, 1911, a day when etesiens were experienced.

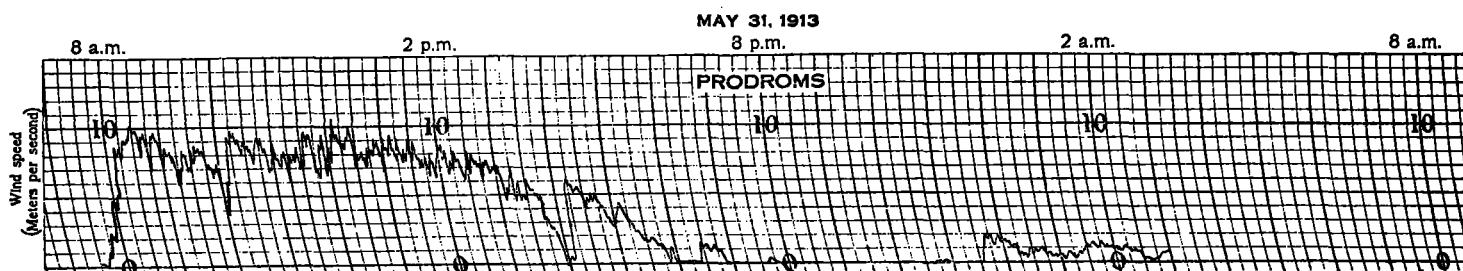


FIG. 2.—Anemocinemographic record from the National Observatory at Athens for May 31, 1913, a day when prodroms were experienced.

Direction of the etesiens.—The difference in the direction of the etesiens in the Aegean and Ionian Seas was noted as early as the time of Aristotle, who wrote as follows:

The etesiens blow in the west part of the country from N. to W. (W=Zephyros. Zephyros is really a north wind.) During the day the direction of the etesiens is changing, beginning with north in the morning through NW. until in the evening they blow from the west: in the eastern part of the country their direction is between N. to E. as far as Apeliotis (=East).

The direction of the etesiens varies from the Aegean to the Ionian Sea—that is, the etesiens in the west blow from the directions N. to W. and in the east they blow from the directions N. to E.

According to our observations the exact direction of the etesiens is NW. in the Ionian Sea and NE. in the north Aegean Sea. In the southern Aegean Sea the direction becomes north (Naxos, Santorini), and near the northern coasts of Egypt it becomes northwest. This is, of course, the direction in the open sea. At the island of Andros (Aegean Sea), for instance, the prevailing direction is the NW. instead of NE., but this is due to local circumstances. In Athens the direction of the etesiens is NNE. to NE.

Velocity and diurnal oscillation of the etesiens.—From the study of our anemometric data we see that the

During the night their velocity was low, as, for example, 6 m/s. on the night of August 9–10. Their maximum velocity occurs during the months of their highest frequency (July and August).

The diurnal change of their velocity was also observed by the ancients. Aristotle writes:

The etesiens and the prodroms are weaker during the night.

The etesiens blow after the solstice and the morning rising of Sirius, they do not blow when the sun is nearest or when it is farthest away; they blow during the day and cease at night.

Why do the etesiens blow always during the same season and so strongly? And why, when the day ends, do they stop and do not blow at night? Is it because the snow is not melted by the sun in the evening and at night? And they blow fully when the sun begins to melt the northern ice. When the ice begins to melt, the prodroms blow and when it is melted the etesiens.

In the case of the prodroms the velocity is less. It varies between 4 and 8 meters per second (9–18 miles per hour), sometimes reaching 10 meters per second (22½ miles per hour) at the time of the highest temperature. It diminishes in the afternoon and vanishes at night.

The following graphs of the anemocinemograph at the Observatory of Athens give a clear idea of the diurnal variation of the etesiens (Fig. 1) and the prodroms (Fig. 2).

Differences between the Aegean and the Ionian Seas.—A comparative study of the frequency of the etesiens in the Aegean and the Ionian Seas shows that these winds blow simultaneously in both seas. However, the records of the station of the city of Corfu show a marked deficiency which is due to purely local causes. In the case of the prodroms, there exists a difference between the two seas. In the Aegean Sea the prodroms have their greatest frequency toward the last 10 days of May, after which they diminish until about the 10th of June. In the Ionian Sea, the island of Corfu alone has the same distribution as the Aegean Sea. As we go farther south in the Ionian Sea we find a continuous increase in the frequency of north winds from the beginning of May until July and August. In other words, in the records of the southern Ionian stations the separation of prodroms and etesiens is not apparent. Examining the run of the isobars on southeastern Europe and the east Mediterranean Sea, we see immediately that their distribution is quite different in the Ionian and Aegean Seas. In the Ionian Sea, from May to September, i. e., during the time when the prodroms and etesiens blow, their direction is from north to south without any interruption, giving an almost continuous régime of north winds.

Table 3 shows that the prevailing winds in Greece are the northern ones. Because of this fact it is clearly difficult to recognize the etesiens, not perhaps during their principal phase, but at least during their beginning and their end. Not infrequently one can be mistaken in recording as etesiens simple north winds having no relation to the etesiens. During the month of August, when the etesiens reach their maximum, there is formed over Ungaria an area of high pressure which remains there, becoming stronger during September and joining in October the Russian anticyclone area, forming with it an anticyclonic system very characteristic in Greece during the winter. Because of this high-pressure area, north winds having no relation to the etesiens blow in Greece. In order to recognize the etesiens it is therefore indispensable to study their origin and their different features.

ORIGIN OF THE ETESIENS.

Distribution of the atmospheric pressure.—In winter the eastern Mediterranean Sea and the surrounding countries are subjected to the influence of two great centers of energy, first the Asiatic high-pressure area and second the Atlantic high-pressure area. The distance between these two areas of high pressure is very great, so that the prevalence of local conditions on the Mediterranean Sea is not uncommon.

During the winter, barometric lows are very frequently moving over the Mediterranean from west to east. The velocity of displacement of these low-pressure areas is sometimes so great that it is impossible to compare isobaric charts made 48 hours apart. If considering only the influence of the Asiatic high-pressure area we would expect to have in winter on the Greek peninsula a continuous current of northerly winds, but the mentioned low-pressure areas change the situation entirely; the wind system becomes quite irregular and its study difficult.

In summer the distribution of the pressure undergoes an essential change. The Asiatic high-pressure area still persists, displaced, however, toward the north; it penetrates through the Iberic peninsula into central and southern Europe as far as the Ionian Sea, with a tendency to form a secondary maximum (762 mm.) north of the Grecian peninsula.

TABLE 3.—Prevailing winds.

Year.	Ath-ens.	An-dros.	Naxos.	Syra.	San-torin.	Chal-cis.	Corfu.	Argos-toli.	Zante.	Pa-tras.
1900.....	ne.	n.	n.	n.	n.	n.	wnw.	nw.	nw.	n.
1901.....	ne.	nw.	n.	nne.	nw.	n.	se.	nw.	n.	n.
1902.....	ne.	n.	n.	n.	n.	n.	se.	nw.	nw.	n.
1903.....	ne.	nw.	n.	n.	w.	n.	nw.	nw.	nw.	sw.
1904.....	ne.	nw.	nne.	n.	nne.	n.	se.	nw.	nw.	ne.
1905.....	ne.	nw.	n.	n.	nw.	n.	se, nw.	nw.	nw.	ne.
1906.....	ne.	nw.	n.	n.	n.	n.	nw.	nw.	nw.	ne.
1907.....	nne.	n.	nne.	n.	n.	n.	nw.	nw.	nw.	n.
1908.....	ne.	n.	n.	n.	n.	n.	ne.	nw.	nw.	ne.
1909.....	ne.	n.	nne.	ne.	w.	n.	w.	nw.	nw.	w.
1910.....	ne.	n.	nne.	ne.	w.	n.	w.	se.	nw.	?
1911.....	ne.	n.	n.	ne.	n.	nw.	n.	se.	nw.	w.
1912.....	ne.	n.	nne.	n.	w.	nw, s.	se.	nw.	nw.	w.
1913.....	ne.	n.	nne.	n.	n, w	nw.	sw, nw.	nw.	nw.	w.
1914.....	ne.	n.	nne.	n.	n, w	n.	s.	nw.	nw.	n.

The pressure gradually diminishes from -25° to $+30^{\circ}$ latitude. In Asia, instead of the winter anticyclone, a very deep, low area "the proasiatic cyclone" is formed, having its center (below 748 mm.) located at 30° northern latitude and 65° longitude east from Greenwich, i. e., north of eastern Persia. This low area is very well known as the origin of the Asiatic monsoon winds.

During the summer the influence of the Mediterranean Sea upon the run of the isobars is very much less than in winter. The above two centers of energy which prevail during the summer, i. e., the Atlantic high-pressure area and the proasiatic cyclone, are close together and the Mediterranean, where in summer disappear the causes of the formation of the local areas of low pressure, can not modify the regular decrease of the pressure from NW. to SE.³

During the warm months the pressure over the Mediterranean is decreasing gradually from W. to E. and from N. to S. toward Africa, so that a uniform barometric situation is created, producing winds blowing between NW. and NE. until the month of September and even longer. The proasiatic cyclone begins to influence the east Mediterranean the later part of May, i. e., at the time when the prodroms begin to blow. At that time, however, the low-pressure area is not fully developed, and, besides, the Atlantic high-pressure area has not yet penetrated into Europe.

The distance of these two centers is great and their mutual influence on the Mediterranean not very important.

The proasiatic low-pressure area, growing in June, extends toward the north while no appreciable change of the gradient on the Mediterranean is observed. By that time the high temperatures of the summer favor the production of the local winds which prevail during this month. In July the two centers are finally developed and the etesiens become the prevailing winds of the eastern Mediterranean. The proasiatic low-pressure area, the cause of the Indian monsoons, is the cause of the etesiens. In other words, we may say that the etesiens belong to the same cyclonic system as the monsoons. It is true that the Atlantic high-pressure area which penetrates into Europe, and the formation of the secondary high-pressure north of Greece, do reinforce the etesiens but their origin is due to the proasiatic low-pressure center.

Even in May, where there is no influence of the Atlantic high pressure, we notice in Greece the prodroms, signs of the later prevalence of the proasiatic low-pressure area. So, the etesiens are not local winds, due to limited and local causes; they belong to the great system of the proasiatic low pressure and are connected with the Indian monsoons.

³ See Julius von Hann *Die Luftdruckverteilung über Mittel und Süd Europa.*

Variation of the atmospheric pressure. Diurnal variation of the velocity.—The monthly means of the pressure of 65 years' observations in Athens (1839–1903), follows:

	mm.		mm.
January.....	754.45	July.....	749.92
February.....	753.76	August.....	750.38
March.....	751.39	September.....	752.57
April.....	751.04	October.....	753.74
May.....	751.22	November.....	754.06
June.....	750.92	December.....	753.54

As we see from this table, the minimum occurs during the summer. At that time the Atlantic high pressure occupies west Europe, but Greece and the eastern Mediterranean are controlled by the proasiatic low pressure. The above minimum of the barometric pressure coincides with the greatest frequency of the etesiens. During the season of the etesiens the pressure in Greece generally is almost normal. But, if we examine the daily values of it, we find that the pressure increases when they blow and it decreases when they stop. Ordinarily, the days with etesiens are characterized by an increase of the atmospheric pressure.

TABLE 4.—Mean barometric pressure at Athens Observatory.

[Height above sea level 33 feet. Mean of observations at 8 hr., 14 hr., and 21 hr.]

Date.	Pressure (reduced to 0°C.).	Date.	Pressure (reduced to 0°C.).
	mm.		mm.
May 14.....	748.80	June 10.....	750.70
15.....	750.30	11.....	750.97
16.....	753.83	12.....	751.53
17.....	753.33	13.....	750.63
18.....	749.87	14.....	749.57
19.....	749.37	15.....	749.50
20.....	748.27	16.....	749.97
21.....	748.27	17.....	752.40
June 1.....	751.37	18.....	752.23
2.....	753.50	19.....	751.37
3.....	754.20	20.....	751.17
4.....	752.60	July 5.....	752.13
5.....	753.23	6.....	753.27
6.....	753.23	7.....	753.30
7.....	754.17	8.....	752.80
8.....	753.23	9.....	752.27
9.....	750.67	10.....	752.27

¹ Indicates days of etesiens.

Table 4 gives an idea of the variation of pressure for Athens. In making the following explanation of this phenomenon we have found especially useful the "Daily Weather Reports of Cairo." The Aegean Sea is found, during May and the summer months, to be under the influence of the proasiatic low-pressure area, and the etesiens blow there almost continually. But in continental Greece and the Ionian Sea the gradient is relatively small. Two causes contribute to reinforce this gradient: (1) *In May* the barometric high-pressure area of Tripoli (North Africa) which often extends toward the northeast and, (2) *in summer* the Atlantic high-pressure area which penetrates into Europe as far as the Danubian countries. These two areas of high pressure increase the barometric pressure over Greece a little during the time of the etesiens. Without the existence of these two maxima the etesiens would undoubtedly be weaker and less frequent.

In regard to the diurnal change of the pressure during the days of etesiens, the study of the graphs of the Observatory of Athens shows that there is no appreciable change of the regular double diurnal oscillation.

It was believed that the diurnal change of the velocity was due to the overheating during the day and the cooling during the night of the Lybian Desert (North Africa), which accordingly during the day acts like an

aspiration center and during the night stops the flow of the air coming from the north. Although this explanation seems simple, I do not believe it is the correct one.

On the coasts where the sea breeze is observed, a certain time between sunrise and 9 or 10 a. m. is required to establish this aerial current in a radius not exceeding 20 or 30 kilometers. It does not seem reasonable, therefore, to assume that from sunrise until 8.30 or 9 a. m. a strong aerial current may be established between the parallels 39° and 29° N., i. e., covering a distance of more than 1,000 kilometers, the difference of the pressure between the Lybian Desert and Greece being 1 and 2 mm. during the days of etesiens.

The direction of the gradient is west-east. East of Greece, at a distance of almost 220 kilometers, is Asia Minor. The sun, owing to the diurnal revolution of the earth, sets first in Asia Minor and afterward in Greece. The Asiatic Continent, hot during the day time, cools off quickly during the clear summer nights. The result is the diminishing of the gradient between it and Greece, and consequently the weakening of the etesiens. The opposite thing is observed after sunrise. In other words, the location of Asia Minor contributes to the reinforcement of the etesiens after sunrise and to their weakening after sunset, the diurnal range of temperature being greater in Asia Minor than in Greece, which is surrounded by the sea. If at any time the local conditions of humidity, cloudiness, etc., over Asia Minor are such as to prevent the normal cooling process during the night, the etesiens continue to blow even at night almost as strong as during the day.

The meteorological elements during the time of etesiens.—Since the etesiens blow from the north quadrant they become hotter, going more and more toward the south. In Athens and especially in continental Greece, where they have to go through the hot continent they arrive dry, and in spite of the fresh sensation they offer to the body on account of the evaporation, the temperature during the day is mostly higher than the days when the sea breeze blows.

The results are different in the open sea where these winds are really fresh, and moderate the temperature of the summer. They strike the islands as real sea, north winds, fresh and very agreeable, without first being influenced by the land.

TABLE 5.—Meteorological elements at Athens.

	Maxi- mum temper- ature.	Humid- ity (rela- tive).	8 a. m.— 9 p. m., evapora- tion.	Wind.
	° C.	Per cent.	mm.	
July 19.....	33.0	42	5.7	Etesiens.
20.....	30.6	36	6.0	Do.
21.....	30.6	32	6.4	Do.
22.....	31.2	34	6.6	Do.
23.....	30.2	31	6.4	Do.
24.....	29.2	23	6.0	Do.
25.....	30.9	30	6.0	Do.
26.....	32.0	29	6.6	Do.
27.....	35.0	19	8.0	Do.
28.....	29.8	32	6.2	Do.
29.....	29.7	38	4.8	Do.
30.....	31.1	32	5.2	Do.
31.....	28.6	43	4.2	Sea breeze.

The dryness of the etesiens and their high temperature give to Athens clear skies and high evaporation. Table 5 gives for Athens the maximum temperature of the days with etesiens, the relative humidity at 2 p. m. (Athens legal time), and the quantity of the evaporated water between 8 a. m. and 9 p. m.

Clear skies is one of the outstanding features of the etesiens. In Greece, where the prevailing winds are the northern ones, one must give close attention in order to discriminate between them and the etesiens.

A consequence of the dryness is the lack of rain when the etesiens blow. Sometimes, but very seldom, the etesiens are accompanied by cloudy sky and bad atmospheric transparency, as in the case of sirocco.

Physiologic influence of the etesiens. Influence upon the vegetation. Importance for navigation.—In spite of the vivifying influence of the etesiens upon the human body, due chiefly to evaporation, they are disagreeable from another point of view, especially in the city of Athens.

Contributing to a great extent to the dryness of the soil, they raise by their motion great quantities of dust. Sometimes when the etesiens blow, Athens disappears in a cloud of dust; plants are covered with dust, and generally it becomes very unattractive to stay in Athens. It is only during the night, when their velocity diminishes and the dust falls, that it is possible to feel their benevolent influence.

Even in the islands the etesiens are not always agreeable. Their velocity is very often so high that it is not at all pleasant to stay out in the open air. Furthermore vegetation suffers very much from the etesiens. Not only are the plants covered with dust but they are violently shaken; flowers and leaves are detached as in autumn. That is why the inhabitants of the Aegean Islands are obliged to take precautions against the etesiens, protecting the orchard trees by rows of cypresses.

The velocity of the etesiens in the Aegean Sea is frequently very high, almost stormy, making navigation very dangerous. It is a well-known fact that at that time boats can not approach the harbors of the Aegean Islands, because of the very rough sea.

These winds descending toward the south from the mountains become violent and dangerous (fall winds). Dangerous places known to navigators are the south coasts of Euboea, the south coasts of the islands Andros, Tinos, and Crete, and the rocky coasts of Maleas (south Peloponnesus).

Ancient history is rich in examples showing clearly the prevailing influence of the etesiens upon the communications and the marine relations of the inhabitants of the Aegean Islands. To-day, also, during the season of the etesiens, sailboats can not go through the Darda-

nelles and reach the sea of Marmora and the Black Sea. It is not uncommon to see a great number of them (sometimes over 200), waiting at the island Tenedos for a favorable wind in order to enter the Dardanelles.

In antiquity these winds favored colonization, being of appreciable value to communication between Greece and her colonies to the north. During their season it was very easy to transport crops from the agricultural colonies of the Black Sea as far as Greece. But, on the other hand, they prevented the arrival of help sent from Greece to the northern colonies in case of emergency. An enemy like Philip of Macedonia, putting forward his plans rapidly and secretly, found very great help in the etesiens. It was really very dangerous and irksome for the Athenian fleet to sail toward the north, being obliged to use the oars. For this reason the ancient Greeks observed the etesiens and tried to determine as accurately as possible the date of their beginning, their period, their interruptions, etc. The etesiens are not limited to the Aegean and the Ionian Seas. They also blow over the Black and the Marmora Seas and mostly over the Bosphorus. They blow continually during four to six weeks, under a clear sky as far as the coasts of North Africa.

Prediction of the etesiens.—In summer, during the season of the etesiens, weather changes in Greece are almost unknown. High temperature, clear skies, dryness, local heat thunderstorms, accompanied sometimes by hail, are the general features of the summer season. As soon as the reinforced proasiatic low-pressure area extends as far as the Grecian Seas, the etesiens begin to blow over the Aegean Sea and the oriental coasts of Greece. These are not very strong and are interrupted by the local winds. Little by little when the high pressure over the Danube countries begins to develop, the etesiens become stronger and steadier. Their prevalence in Greece is preceded by a small, gradual increase in the pressure under a clear sky.

On the Aegean Sea the etesiens blow during almost the whole summer, so that we can say that they do not need to be predicted. Their velocity increases with the pressure and often reaches force 9 of the Beaufort scale, when the sea becomes dangerous even for the largest boats. So far we do not know any particular local signs for predicting the etesiens. Sailors sometimes predict the etesiens from little clouds floating over the tops of the high mountains.